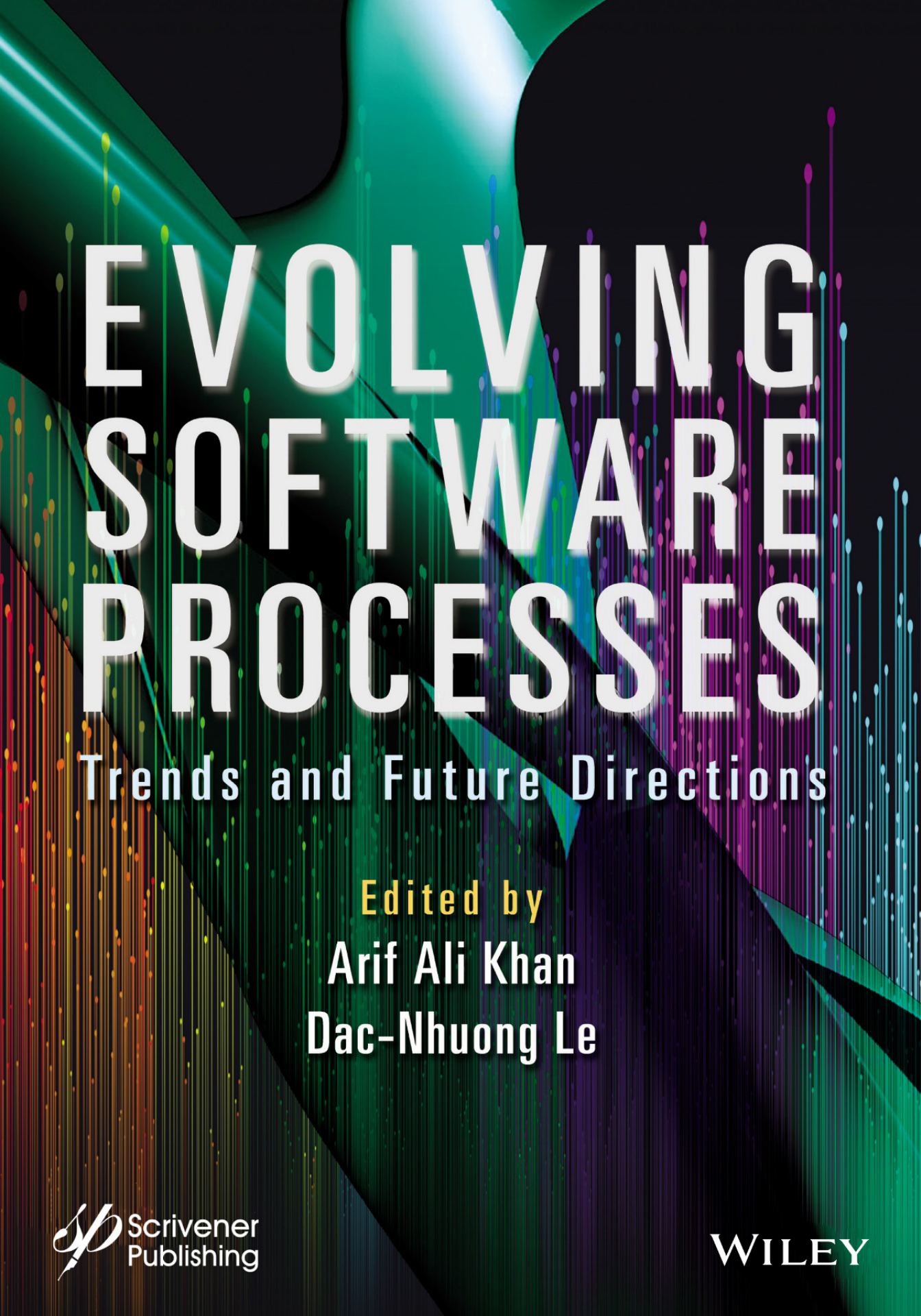
EVOLVING SOFTWARE PROCESSES
Trends and Future Directions
Edited by
Arif Ali Khan
Dac-Nhuong Le
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Evolving Software Processes

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Dedicated to our friends
and family for their
constant support during the
course of this book

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Foreword

A number of books have been written over the years about improving the software process, some of them quite good, some less so. Arif and Dac-Nhuong Le have edited a book that I will be happy to add to my library. They have been involved in software process assessment and improvement for years, so they have the experience necessary to speak knowledgeably about the topic. They have included interesting chapters in this book that I think are important for systematic process improvement and management in today's industrial evolution.

The development processes in the software industry continue to evolve tremendously and it takes innovative efforts to cope with the global challenges. For instance, the present COVID-19 pandemic situation is reshaping the software industry working environment and is driving continuous changes in the software engineering processes, methods and collaborative software development environment. Industry will see the long-term effects in the coming years. It is a struggle to reform the working environment and specifically the software processes that are seriously affected by the 2019 pandemic.

One might argue that there are already many books that include descriptions of software processes. The answer is "yes, but." Becoming acquainted with existing software processes is not enough. It is tremendously important to understand the evolution and advancement in software processes so that they appropriately address the problems, applications, and environments to which they are applied. Providing basic knowledge for these important tasks is the main goal of this book.

Industry is in search of software process management capabilities. The emergence of the COVID-19 pandemic emphasizes the industry's need for software with specific process management capabilities. Most of today's products and services are based to a significant degree on software and are the result of large-scale development programs. The success of such programs heavily depends on process management capabilities, because

they typically require the coordination of hundreds or thousands of developers across different disciplines. Additionally, software and system development is usually distributed across geographical, cultural and temporal boundaries, which make the process management activities more challenging in the current pandemic situation. It is vital for software development organizations to address the quality challenges by improving the organizational practices and processes. A mature software process can assist an organization in successfully executing software development activities.

This book provides the basic building blocks used in the evolution of software processes, such as DevOps, agile processes management, process assessment for human resources, recommendation models for process improvement and security, in order to lay a solid foundation for successful and sustainable future processes.

I would like to congratulate the editors of this volume, Arif Ali Khan and Dac-Nhuong Le, for compiling such timely and comprehensive research contributions. The diversity of topics covered by different chapters and the profiles of contributing authors, who are internationally established researchers, is very impressive. Different chapters describe cutting edge research efforts that try to get to the depth of many of the abovementioned challenges, with an overall aim of providing a detailed literature review, starting from fundamental concepts to more specific technologies and application use cases. I firmly believe that this edited book will provide a comprehensive resource to students, researchers, and practitioners, and have a long-lasting positive impact on this important and growing research and technological field.

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University of Jyväskylä, Finland
September 2021

Preface

The extremely comprehensive overview of the evolution in software processes given in this book makes it very valuable for a wide audience of interested readers. This book specifically provides a platform for practitioners, students and researchers to discuss the studies used for managing aspects of the software process, including managerial, organizational, economical and technical. It provides an opportunity to present empirical evidence using available managerial, organizational, economical and technical strategies of software processes, as well as proposes new techniques, tools, frameworks and approaches to maximize the significance of software process management.

The following studies are discussed in the 14 chapters of this book.

- In Chapter 1, Sujin Choia, Dae-Kyoo Kimc, and Sooyong Park propose a novel recommendation model (i.e., ReMo), which to enables systematic development of quality recommendations through rigorous analysis of assessment findings.
- In Chapter 2, Monica Iovan, Daniela S. Cruzes, and Espen A. Johansen describe the practical solutions in one systematic model for purposely disseminating innovations in software security practices through careful attention to the stages of effective and sustainable implementation of the software security program. The goal of the proposed framework is to enable software organizations to create a sustainable security program that ensures that software teams continue to use the practices that improve and address the security of the products, hence adopting a long-term perspective.
- In Chapter 3, Luis Fernández-Sanz, Inés López Baldominos and Vera Pospelova develop the bridge between software processes and IT professionalism frameworks. They discuss the missing relationships between processes and activities in software development projects, the job profiles involved in them, and the skills recommended for effective performance.
- In Chapter 4, Avais Jan *et al.* incorporate earned value management (EVM) into agile software development. They propose a novel framework to tackle the key EVM challenges in agile environment.
- In Chapter 5, Vishal Pradhan, Ajay Kumar and Joydip Dhar propose a process model to understand the reliability of open source software (OSS) system releases. The effectiveness of the proposed model is assessed based on the experimental results, which revealed that it is an efficient reliability model for multi-release OSS.

- In Chapter 6, Murat Tahir Çaldağ and Ebru Gökalpb present an open data capability maturity model (OD-CMM) they developed to evaluate the open data capabilities of an organization and provide a road map for further improvements. The model is developed based on the concepts of ISO 330xx family of standards.
- In Chapter 7, Abdul Wahid Khan *et al.* present a systematic literature review (SLR) and industrial survey study, which they conducted to develop a conceptual map of the success factors that could impact the outsourcing of human resources in the domain of global software development (GSD). A total of thirteen success factors are identified, which are further classified across four main categories.
- In Chapter 8, Shahid Hussain proposes a process framework to address the classification problem of security and non-security bug reports. The framework identifies the important security-related keywords from the security bug reports (SBR) and removes these keywords from the non-security bug reports (NSBR) to improve classification decisions. The framework is empirically evaluated and the results indicate its significance in terms of classification of the SBRs.
- In Chapter 9, Mohammad Shameem presents an SLR study he conducted to identify the challenging factors that could negatively impact the DevOps practices in software development organizations. The SLR study revealed a total of 16 challenging factors, which were further analyzed to reveal the most significant factors. Finally, the identified factors were analyzed across the development and operation silos of DevOps practices.
- In Chapter 10, Muhammad Shoaib Khan, Abdul Wahid Khan and Javed Khan present an SLR protocol to identify the cultural challenges in the DevOps environment. The ultimate goal of the study was to develop a DevOps culture challenges model (DC2M) to improve communication, coordination, understanding, and trust, and to reduce the barriers between development and operation silos.
- In Chapter 11, Noor Rehman and Abdul Wahid Khan report on the barriers of IoTbased software architecture. The SLR approach was used to explore the available primary studies and a total of 20 barriers were identified, which were further analyzed based on different continents.
- In Chapter 12, Sher Badshah addresses the project management challenges in the GSD environment. The sutdy's findings consist of a total of 25 challenges that could be potential barriers for project management activities in GSD. Finally, the identified challenges are mapped into the knowledge areas of the project management body of knowledge (PMBOK) framework.
- In Chapter 13, Shah Zaib, Abdul Wahid Khan and Iqbal Qasim discuss cybersecurity challenges. The SLR approach was adopted and identified a total of 13 challenging factors. The challenging factors were also analyzed based on the digital repositories of the primary studies and the adopted research methods.
- In Chapter 14, Ebru Gökalp presents the capability maturity model he developed to improve the digital transformation (DX) human resource skill development process in an organization. The proposed model is based on the

concepts of ISO 330xx family of standards. The industrial evaluation of the model shows that the proposed approach is applicable to assess the current DX human resource skill development capability level of an organization and provide best practices to move to the next maturity level.

Since it disseminates cutting-edge research that delivers insights into the tools, opportunities, novel strategies, techniques, and challenges for managing software processes, this book will be a useful resource for practitioners, students and researchers alike.

Practitioners and executives will learn what impact the evolving software processes can have on their projects. They will see ways in which the frequent and continuous change in today's software processes can help to develop software that is faster and more flexible with regard to customer needs. Those practitioners who need to react to the changing requirements by adapting the concepts of continuous development and integration, will read about how DevOps, agile and global software development practices help to live up to these new challenges. This book gives an overview of which methods are used today and how to apply them to a specific project, and includes practices to plan and monitor projects.

Students could benefit from the book by gaining an understanding of the recent trends in software process management. Moreover, it could be used in software engineering degree courses, specifically systematic literature review studies in software process improvement, agile software development, global software development processes, process models, and software project management.

Researchers getting involved with the advanced software processes will find a profound introduction to the subject. They will rapidly become acquainted with these new concepts and understand how these new trends could be used in future research projects.

Arif Ali Khan
Dac-Nhuong Le
October 2021

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We would like to acknowledge and thank the most important people in our lives, our parents and partners, for their support. This book has been a long-cherished dream which would not have been turned into reality without the support and love of these amazing people, who encouraged us with their time and attention. We are also grateful to our best friends for their blessings and unconditional love, patience, and encouragement.

Arif Ali Khan
Dac-Nhuong Le

Acronyms

4GT	Fourth Generation Techniques
AES	Advanced Encryption Standard
API	Application Programming Interface
APF	Adaptive Project Framework
ACWP	Actual Cost of Work Performed
AC	Actual Cost
AHP	Analytical Hierarchy Process
BBSPI	Blockchain-Based Software Process Improvement
BSIMM	Building Security in Maturity Model
BCWS	Budgeted Cost for Work Scheduled
BTK	Bidirectional Transfer of Knowledge
BNS	Bi-Normal Separation
CBDM	Component-Based Development Model
CMMI	Capability Maturity Model Integration
CPM	Concurrent Process Model
CIO	Chief Information Officer
CPI	Cost Performance Index
CSF	Critical Success Factors
CI	Consistency Index
CR	Consistency Ratio
CSCM	Cybersecurity Challenges Model
CSS	Cascading Style Sheets
CSA	Cyber Security Agency
DAST	Dynamic Application Security Testing
DB	Database
DCM	Divide and Conquer Model
DevOps	Development and Operations
DIMM	DevOps Implementation and Management Model
DC2M	DevOps' Culture Challenges Model
DoS	Denial of Service
DX	Digital Transformation
EBSE	Evidence-Based Software Engineering

ESCO	European Skills, Competences and Occupations
e-CF	e-Competence Framework
EQF	European Qualifications Framework
EVM	Earned Value Management
EV	Earned Value
ES	Earned Schedule
FSDM	Formal Systems Development Model
FP	Function Point
FTC	Feature Transition Charts
FPR	False Positive Rate
GMWD	Generalized Modified Weibull Distribution
GSD	Global Software Development
HIPAA	Health Insurance Portability and Accountability Act
HR	Human Resource
IAST	Interactive Application Security Testing
IDC	International Data Corporation
IDR	Incremental Delivery
IoT	Internet of Things
IPs	Improvement Packages
IT	Information Technology
ITIL	Information Technology Infrastructure Library
I/O	Input/Output
ISO/IEC	International Organization for Standardization/International Electrotechnical Commission
ISCO	International Standard Classification of Occupations
ICT	Information and Communications Technology
KPI	Key Performance Indicators
KD	Kolmogorov Distance
LSE	Least Square Estimation
M&A	Measurement & Analysis
MM	Maturity Models
MLE	Maximum Likelihood Estimation
MSE	Mean Square Error
MVF	Mean Value Function
MVC	Model View Controller
NCS	Non-Cognitive Skills
NCSF	Non-Cognitive Skills Framework
NHPP	Non-Homogeneous Poisson Process

NPS	Net Promoter Scores
OMG	Object Management Group
OD-PRM	Open Data Process Reference Model
OD-CMM	Open Data Capability Maturity Model
OECD	Organization for Economic Co-operation and Development
OSS	Open Source Software
OS	Operating System
OWASP	Open Web Application Security Project
OSDO	Offshore Software Development Outsourcing
P2P	Peer-to-Peer
PAs	Process Attributes
PCI DSS	Payment Card Industry Data Security Standard
P-CMM	People Capability Maturity Model
PEOU	Perceived Ease of Use
PIO	Population, Intervention, and Outcome
PMS	Project Management System
PU	Perceived Usefulness
PV	Planned Value
QA	Quality Assurance
QFD	Quality Function Deployment
QoS	Quality of Service
RAD	Rapid Application Development Model
ReMo	Recommendation Model
RQ	Research Questions
RSA	Rivest-Shamir-Adleman
RPM	Rapid Prototyping Model
RFC	Request for Change
RM	Risk Management
RI	Random Consistency Index
SADCM	Software Architecture, Designing Challenges Model
SAMM	Software Assurance Maturity Model
SBR	Security Bug Reports
SCAMPI	Standard CMMI Appraisal Method for Process Improvement
SGA	Structured Gap Analysis
SHA	Secure Hash Algorithm
SLC	Software Life Cycle
SDL	Security Development Life Cycle
SDL-Agile	Security Development Life Cycle for Agile Development
SOA	Service-Oriented Architecture
SPD	Software Process Definition
SPEM	Software & Systems Process Engineering Meta-Model

SPCM	Software Process Certification Model
SPI	Software Process Improvement
SPICE	Software Process Improvement and Capability Determination
SPSS	Statistical Package for Social Sciences
SQL	Structured Query Language
SME	Small and Medium Enterprises
STRIDE	Spoofing, Tampering, Repudiation, Information Disclosure, Denial of Service, and Elevation of Privilege
SSDL	Software Security Development Life Cycle
SV	Schedule Variance
SLR	Systematic Literature Review
SRGM	Software Reliability Growth Model
SSE	Sum of Squares Error
TAM	Technology Acceptance Model
TAMAR	TMMi Assessment Method Application Requirements
TCP/IP	Transmission Control Protocol/Internet Protocol
TIMP	Threat Intelligence Management Platform
TMMi	Test Maturity Model integration
TS	Theil's Statistic
XP	Extreme Programming
XSS	Cross-Site Scripting
XML	Extensible Markup Language
WBS	Work Breakdown Structure
WEF	
WSM	Win-Win Spiral Model
WAN	Wide Area Network
WSN	Wireless Sensor Network
WWW	World Wide Web